

X-524-66-149

NASA TM X-55517

# A TIMING EXPERIMENT USING THE GEOS SATELLITE OPTICAL BEACON

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GPO PRICE \$ \_\_\_\_\_

CFSTI PRICE(S) \$ \_\_\_\_\_

Hard copy (HC) 2.00

Microfiche (MF) .50

ff 653 July 65

MARCH 1966



———— GODDARD SPACE FLIGHT CENTER ————  
GREENBELT, MARYLAND

FACILITY FORM 802

N66 30340  
(ACCESSION NUMBER)

45  
(PAGES)

TMX-55517  
(NASA CR OR TMX OR AD NUMBER)

(THRU) \_\_\_\_\_

(CODE) 1

(CATEGORY) 31

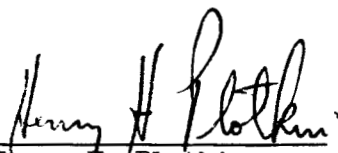
A TIMING EXPERIMENT USING THE GEOS SATELLITE OPTICAL BEACON

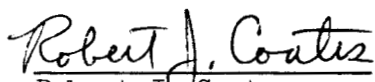
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March 1966

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A TIMING EXPERIMENT USING THE GEOS SATELLITE OPTICAL BEACON

ABSTRACT

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The GEOS I satellite, launched in November 1965, is a gravity stabilized geodetic spacecraft. It is equipped with an optical beacon consisting of four high intensity xenon flash lamps that are programmed to flash at precise times and time intervals.

During the months of February and March 1966, several passes of the GEOS satellite optical beacon flashes were observed photoelectrically at the Goddard Optical Research Facility. A total of 32 flash lamp sequences were observed, recorded and timed relative to the NASA Goddard Cesium Beam Standard. Results of the experiment verified that lamp flashes occur with sufficient accuracy at times programmed into the satellite memory, and indicate that the optical beacon may prove to be useful in checking and possibly synchronizing ground based clocks.

Donald

## PURPOSE

The GEOS satellite, launched in November 1965, is a gravity stabilized geodetic spacecraft having its bottom plane surface always pointing toward the center of the earth. Its orbital parameters are

Apogee	2272.3KM
Perigee	1117.1KM
Period	120.3 Minutes
Inclination	59.4°

On the bottom surface of the GEOS satellite is an optical beacon consisting of four high-intensity xenon flash lamps. The operation of these lamps is controlled by the satellite's memory and stable oscillator (clock). The four flash lamps all point in one direction and may be flashed in any combination of one to four lamps. Flash times are programmed into the satellite memory every 24-48 hours by the Applied Physics Laboratory located in Howard County, Maryland. The memory then controls the flash times of the optical beacon over pre-determined areas of the earth up to 24 hours later. A total of 200 flashes may be programmed during a single orbit.

The optical beacon is programmed in sequences of five or seven lamp flashes, the first flash synchronized to begin within  $\pm 400$  microseconds of the on-board satellite clock minute marker. The time interval spacing between successive flashes in a sequence is on the order of 4 seconds  $\pm 40$  microseconds. The flash duration is 1.2 milliseconds  $\pm 200$  microseconds.

A light output versus time waveform plot (as determined by the EG&G Company prior to the satellite launch date) of a GEOS flash lamp is shown in Figure 1. The light output risetime, as determined from Figure 1 is 80 microseconds (10-90% points) while the lamp pulse duration is 1.2 milliseconds measured at its  $1/3$  power points.

The purpose of the Optical Systems Branch experiment was to determine, based on ground observations and relative to the time standard used by APL and available to all users of GEOS, the following:

- a) The start time of each flash lamp sequence
- b) The time interval between successive flashes within a sequence
- c) The pulse duration of the observed flashes.

#### EXPERIMENT SYSTEM

Figure 2 is a block diagram of the receiver-recorder system used during the experiment. The receiver telescope, the same as is used during the Goddard laser ranging experiments, has an effective aperture of 16 inches (40.6 cm) and a focal length of 300 inches (762 cm). An aperture stop of 1.5 inches (3.8 cm), located directly in front of the receiver phototube, gives a receiver field of view of 17.2 minutes<sup>1</sup>. During a satellite pass the telescope mount is driven along the computed satellite trajectory through the use of a paper tape mount programmer. Since the

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<sup>1</sup>Field of view is determined by the equation  $\theta = 2 \tan^{-1}(\frac{D}{2FL})$   
where  $\theta$  = field of view  
D = diameter of aperture stop  
FL = focal length of telescope.

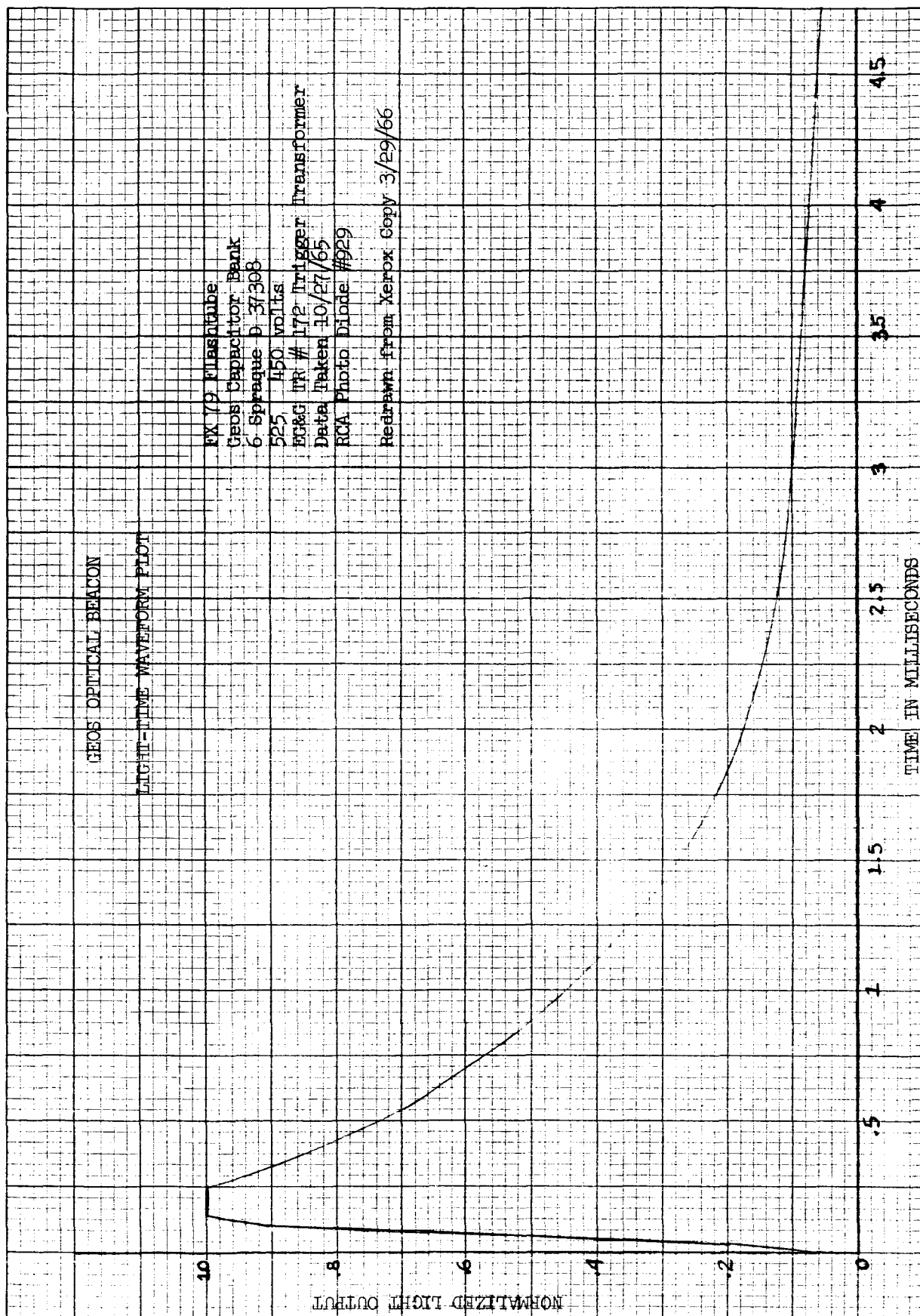


FIGURE 1

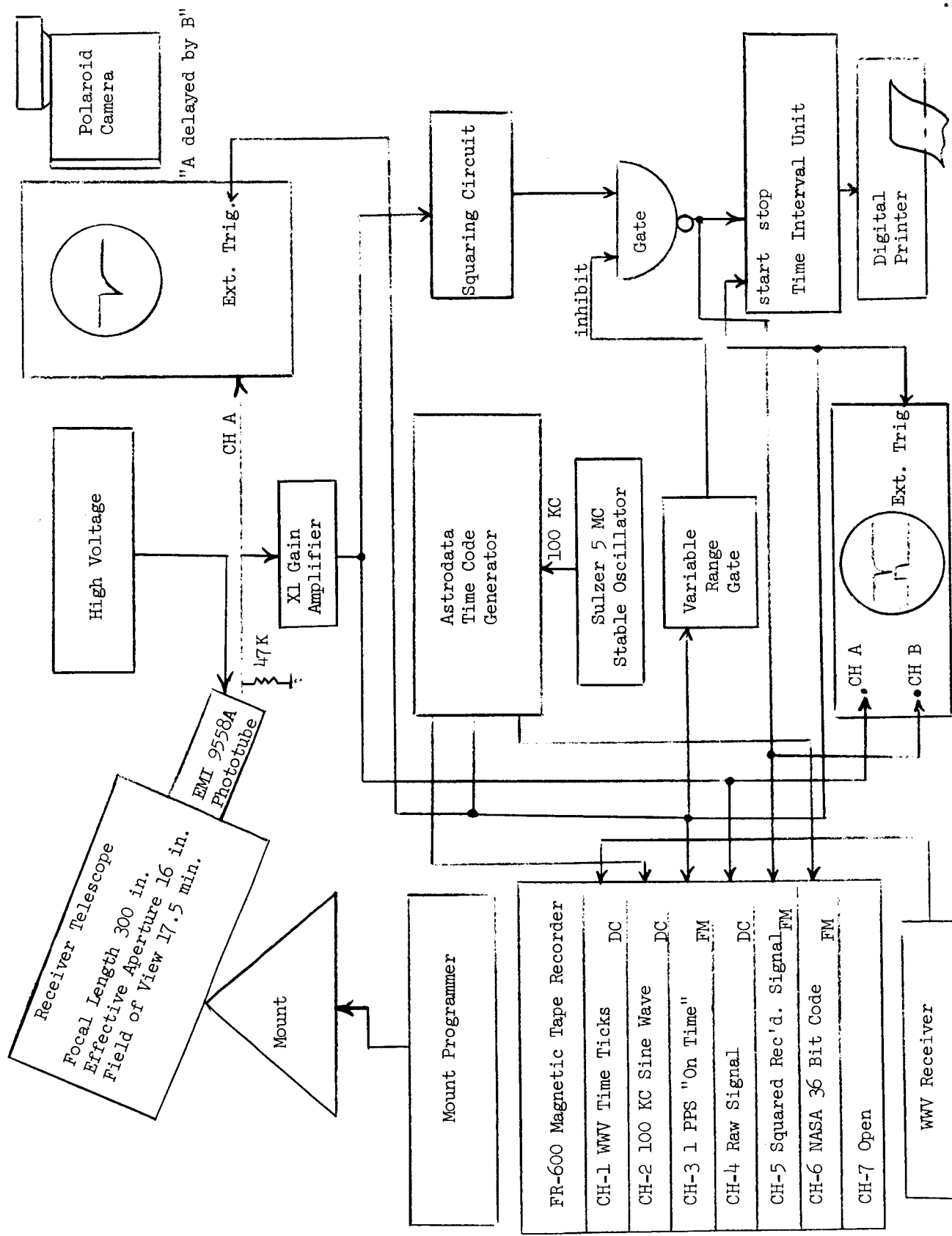


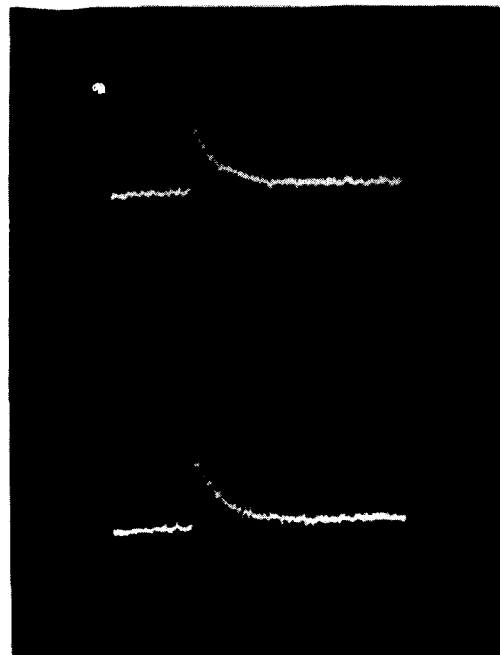
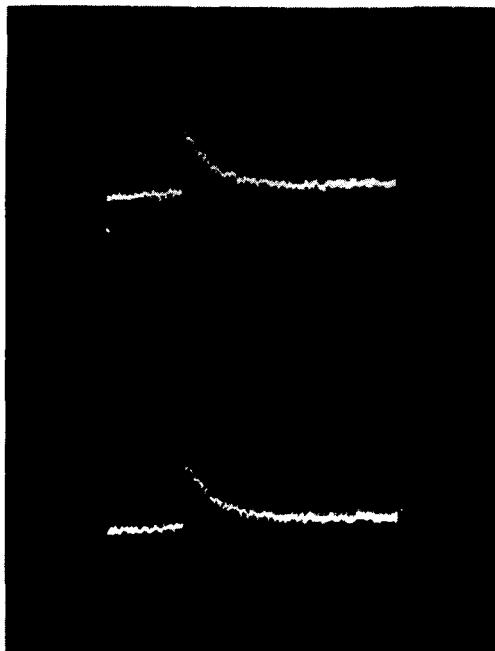
FIGURE 2. GEOS RECEIVER-RECORDING SYSTEM BLOCK DIAGRAM

prediction accuracy and mount movement is sufficient to hold the target within a 10 minute arc circle, it was not normally required to make manual corrections to the programmed drive. When the satellite was in sunlight against a dark sky, it was also possible to view it visually through an auxiliary telescope.

The receiver phototube was an EMI9558A with an S-20 surface. There was no attempt made to filter out a particular line within the xenon output spectrum which approximates daylight; instead the flashes were received unfiltered onto the photocathode surface. The output of the phototube was applied across a 47 kilohm load, and fed to both an oscilloscope and a X1 (unity) gain amplifier, both placed on the platform near the tracking pedestal.

The oscilloscope was located within 15 cable feet of the output of the phototube. Its purpose was to display the undistorted received signal for photographic purposes. The scope trace was initiated by a delayed (5 milliseconds) 1 PPS "on time" pulse generated by our time code generator. The flash lamp signal was thus positioned in the center of the oscilloscope sweep and was photographically recorded through the use of a polaroid camera. Figures 3 through 6 (A&B) show typical flash lamp signals received and recorded directly out of the receiver phototube. The flash lamp signal was simultaneously sent to the unity gain amplifier (cable driver) and recorded on magnetic and paper tape recorders (Figures 7 and 7A).





"A" (4 lamps)

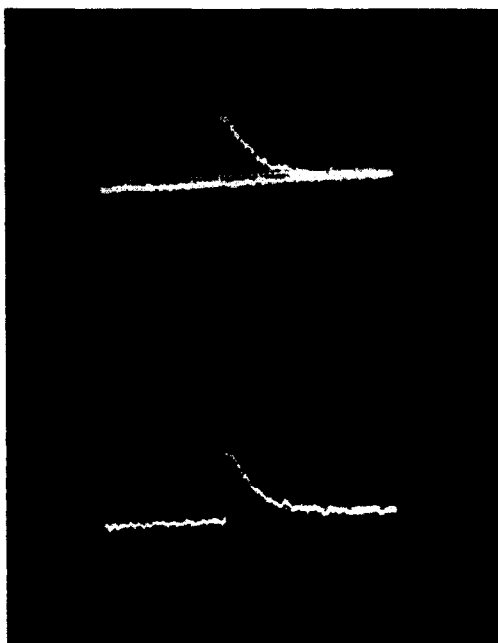
Top - Time  $07^h43^m00^s$  ( $F_1$ )  
 Range 7892 microsec.  
 Bottom - Time  $07^h43^m04^s$  ( $F_2$ )  
 Range 7903 microsec.  
 Sweep 1 ms/cm\*  
 Amplitude 1 v/cm  
 Measured Flash Duration  $\approx$  1.2 millisc.  
 (1/3 power point)  
 Elevation Angle  $\approx 70^\circ$

"B" (4 lamps)

Top - Time  $07^h43^m20^s$  ( $F_6$ )  
 Range 7955 microsec.  
 Bottom - Time  $07^h43^m16^s$  ( $F_5$ )  
 Range 7938 microsec.  
 Sweep 1 ms/cm\*  
 Amplitude 1 v/cm  
 Measured Flash Duration  $\approx$  1.2 millisc.  
 (1/3 power point)  
 Elevation Angle  $\approx 70^\circ$

\*Sweep start delayed 5 milliseconds

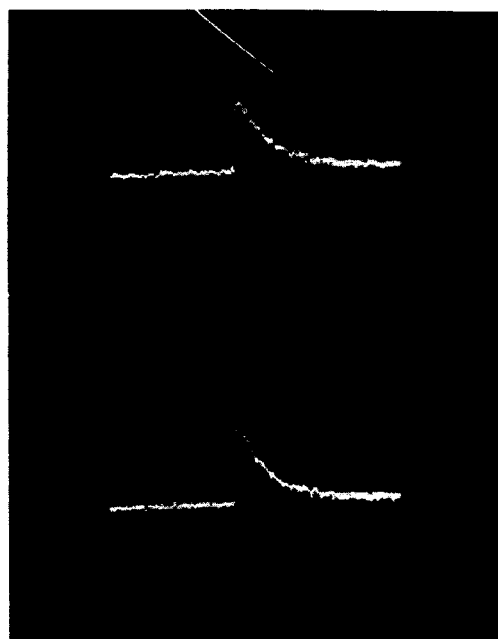
FIGURE 3. Typical 4 Lamp GEOS Flash As  
 Received on March 9, 1966 - Directly Out of Phototube



"A" (4 Lamps)

Top - Time  $07^h47^m00^s$  ( $F_1$ )  
 Range - 9480 microsec.  
 Bottom - Time  $07^h47^m04^s$  ( $F_2$ )  
 Range 9520 microsec.  
 Sweep 1 ms/cm\*  
 Amplitude 1 v/cm  
 Measured Flash Duration  $\approx 1.2$  millisec.  
 (1/3 power point)  
 Elevation Angle  $\approx 44^\circ$

\*Sweep start delayed 5 milliseconds



"B" (4 Lamps)

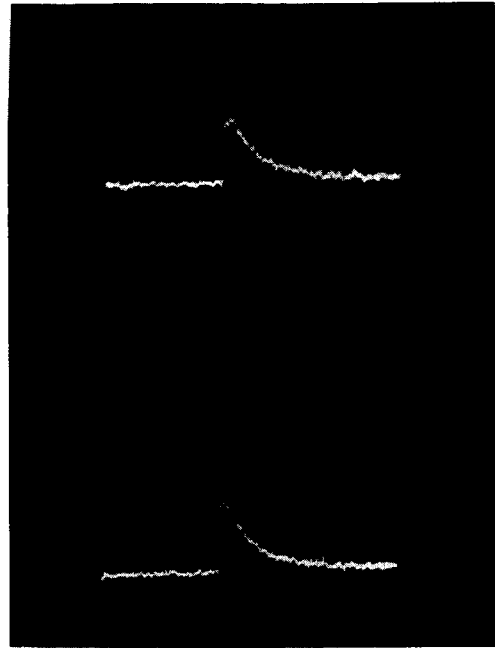
Top - Time  $07^h47^m16^s$  ( $F_5$ )  
 Range 9642 microsec.  
 Bottom - Time  $07^h47^m20^s$  ( $F_6$ )  
 Range 9683 microsec.  
 Sweep 1 ms/cm\*  
 Amplitude 1 v/cm  
 Measured Flash Duration  $\approx 1.2$  millisec.  
 (1/3 power point)  
 Elevation Angle  $\approx 44^\circ$

FIGURE 4. Typical 4 Lamp GEOS Flash As  
 Received on March 9, 1966 - Directly Out of Phototube



"A" (4 lamps)

Top - Time  $09^h41^m00^s$  ( $F_1$ )  
 Range 12,441 microsec  
 Bottom - Time  $09^h41^m04^s$  ( $F_2$ )  
 Range 12,397 microsec  
 Sweep 1 ms/cm\*  
 Amplitude 1 v/cm  
 Pulse Duration  $\approx 1.2$  millisecc  
 Elevation Angle  $\approx 25.0$  deg.

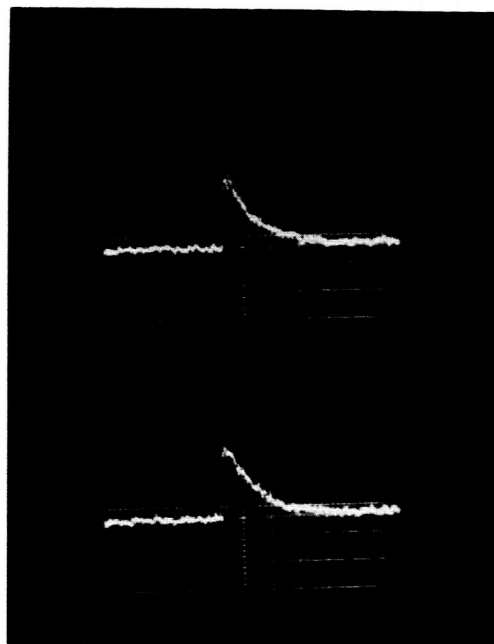
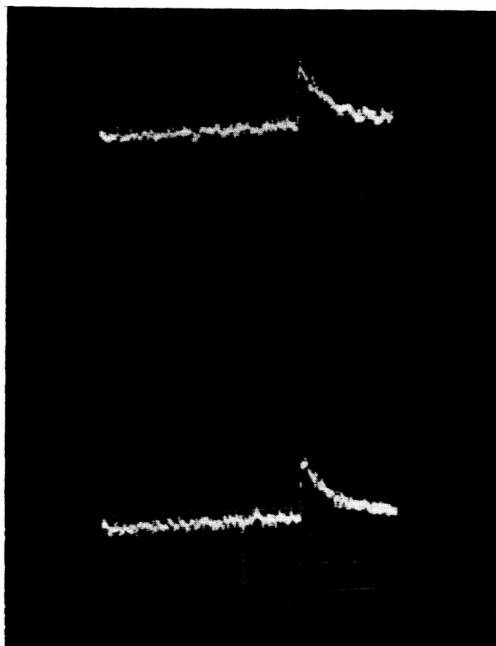


"B" (4 lamps)

Top - Time  $09^h48^m00^s$  ( $F_1$ )  
 Range 9,367 microsec.  
 Bottom - Time  $09^h48^m04^s$  ( $F_2$ )  
 Range 9,358 microsec.  
 Sweep 1 ms/cm\*  
 Amplitude 1 v/cm  
 Pulse Duration  $\approx 1.2$  millisecc.  
 Elevation Angle  $\approx 47.0$  deg.

\*Sweep start delayed 5 milliseconds

FIGURE 5. Typical 4 Lamp GEOS Flash As  
 Received on March 9, 1966 - Directly Out of Phototube  
 (Comparison of Flash Intensity for Like Flashes Within a Sequence)



"A" (4 lamps)

Top - Time  $09^h41^m16^s$  ( $F_5$ )  
 Range 12,264 microsec  
 Bottom - Time  $09^h41^m12^s$  ( $F_4$ )  
 Range 12,308 microsec.  
 Sweep 1 ms/cm\*  
 Amplitude 1 v/cm  
 Pulse Duration  $\approx 1.2$  millisecc  
 Elevation Angle  $\approx 26$  deg.

"B" (4 lamps)

Top - Time  $09^h48^m12^s$  ( $F_4$ )  
 Range 9343 microsec.  
 Bottom - Time  $09^h48^m16^s$  ( $F_5$ )  
 Range 9337 microsec  
 Sweep 1 ms/cm  
 Amplitude 1 v/cm  
 Pulse Duration  $\approx 1.2$  millisecc.  
 Elevation Angle  $\approx 46$  deg.

\*Sweep start delayed 5 milliseconds

FIGURE 6. Typical 4 Lamp GEOS Flash As  
 Received March 9, 1966 - Directly Out of Phototube  
 (Comparison of Flash Intensity for Like Flashes Within a Sequence)

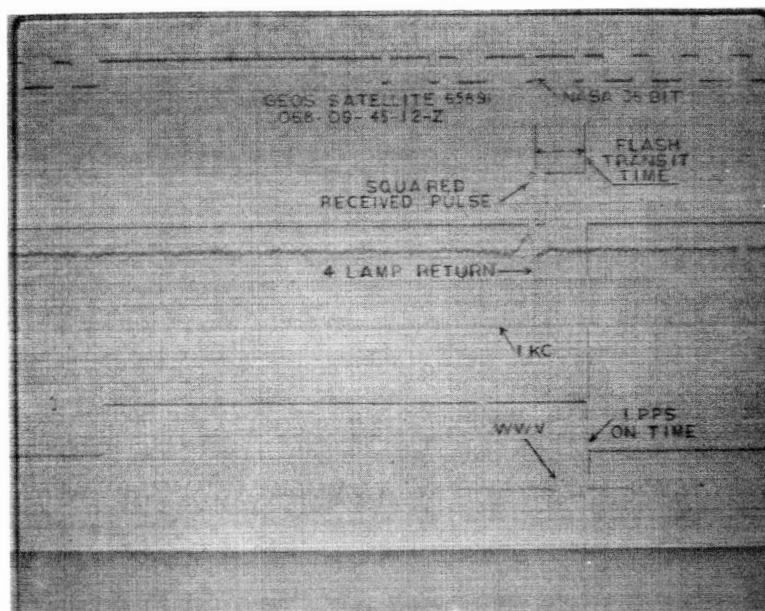


Figure 7. A typical FR600 magnetic tape playback recording onto paper tape of GEOS flash received March 9, 1966 at 09<sup>h</sup>45<sup>m</sup>12<sup>s</sup> (Flash #4) Flash transit time - 10,014 microseconds (as measured from leading edge of 1 PPS "on time" pulse to leading edge of squared received signal). Time increases from right to left.

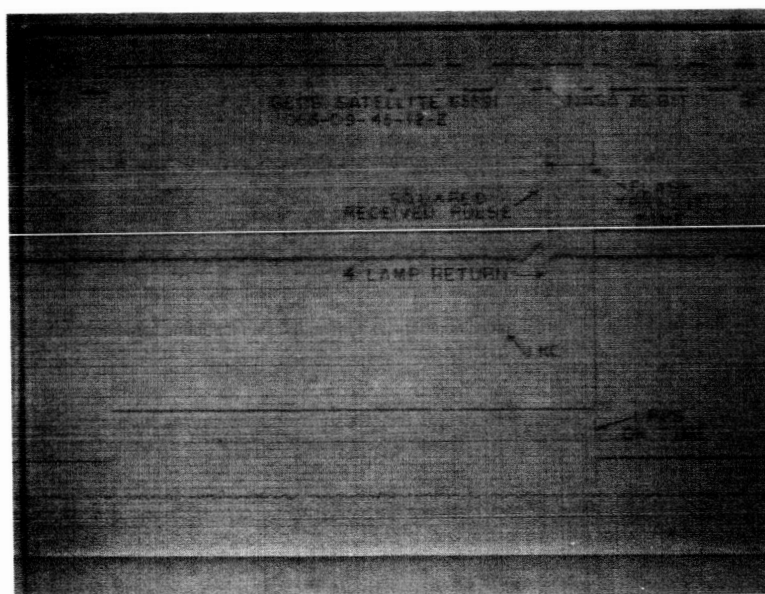


Figure 7A. A typical FR600 magnetic tape playback recording onto paper tape of GEOS flash received March 9, 1966 at 09<sup>h</sup>48<sup>m</sup>12<sup>s</sup>. Flash transit time - 9,218 microseconds (as measured from leading edge of 1 PPS "on time" pulse to leading edge of squared received signal). Time increases from right to left.

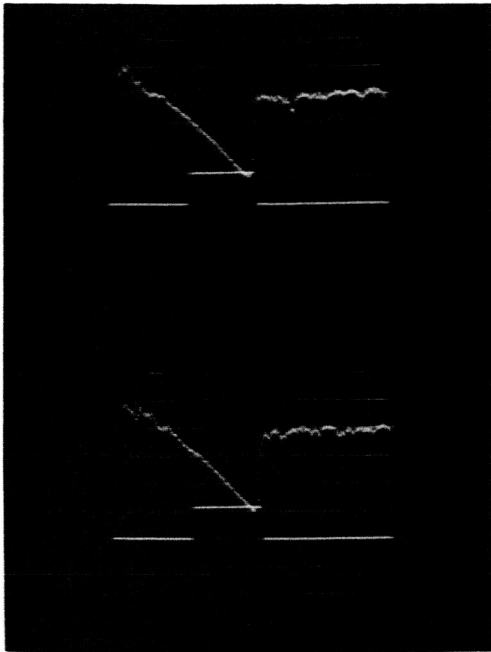
In order to provide a reliable triggering edge for time interval determinations, the flash lamp signal was squared and also recorded. This squared pulse is shown, along with the range gate in Figure 7 and again in Figure 8 A&B. The time interval counter, which had been started by the leading edge of our 1 PPS "on time" marker, was stopped by the squared received signal, thus giving the exact time interval between our reference 1 PPS "on time" marker and the arrival time of the lamp flash signal. The output of the time interval counter was then printed out on paper tape for later re-run comparisons with the data as recorded on the magnetic tape recorder. Data reduction was begun after all flash sequences within a pass were recorded.

#### DATA REDUCTION

The FR-600 magnetic tape recorder has a frequency response of 300 cps to 250 KC using its DC record/reproduce modules and 0-20 KC response using its FM record/reproduce modules. In order to conserve its pulse shape and characteristics, the received flash lamp signal was recorded on a DC channel<sup>\*</sup> while its squared signal counterpart was recorded on an FM channel. The various other timing signals were then recorded on other channels at a tape speed of 60 ips. At the end of a pass the reference 1 PPS "on time" marker, along with the squared received flash returns, were played back from the magnetic tape recording into the time interval counter (Figure 9). The counter was started by the leading edge of the "on time" marker and stopped by the leading edge of the squared received signal. The

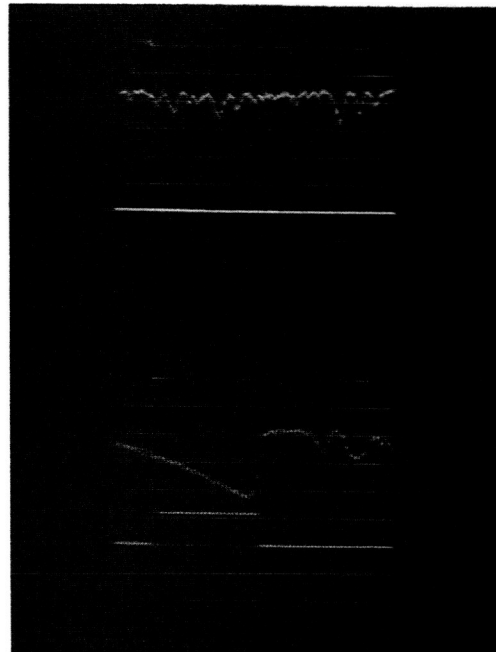
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\*Later results indicate that a differentiated signal applied to a DC record channel is not faithfully reproduced. However, the reproduction does not affect the risetime but only the decay time of the pulse.



"A"

Sweep 500 microseconds/cm

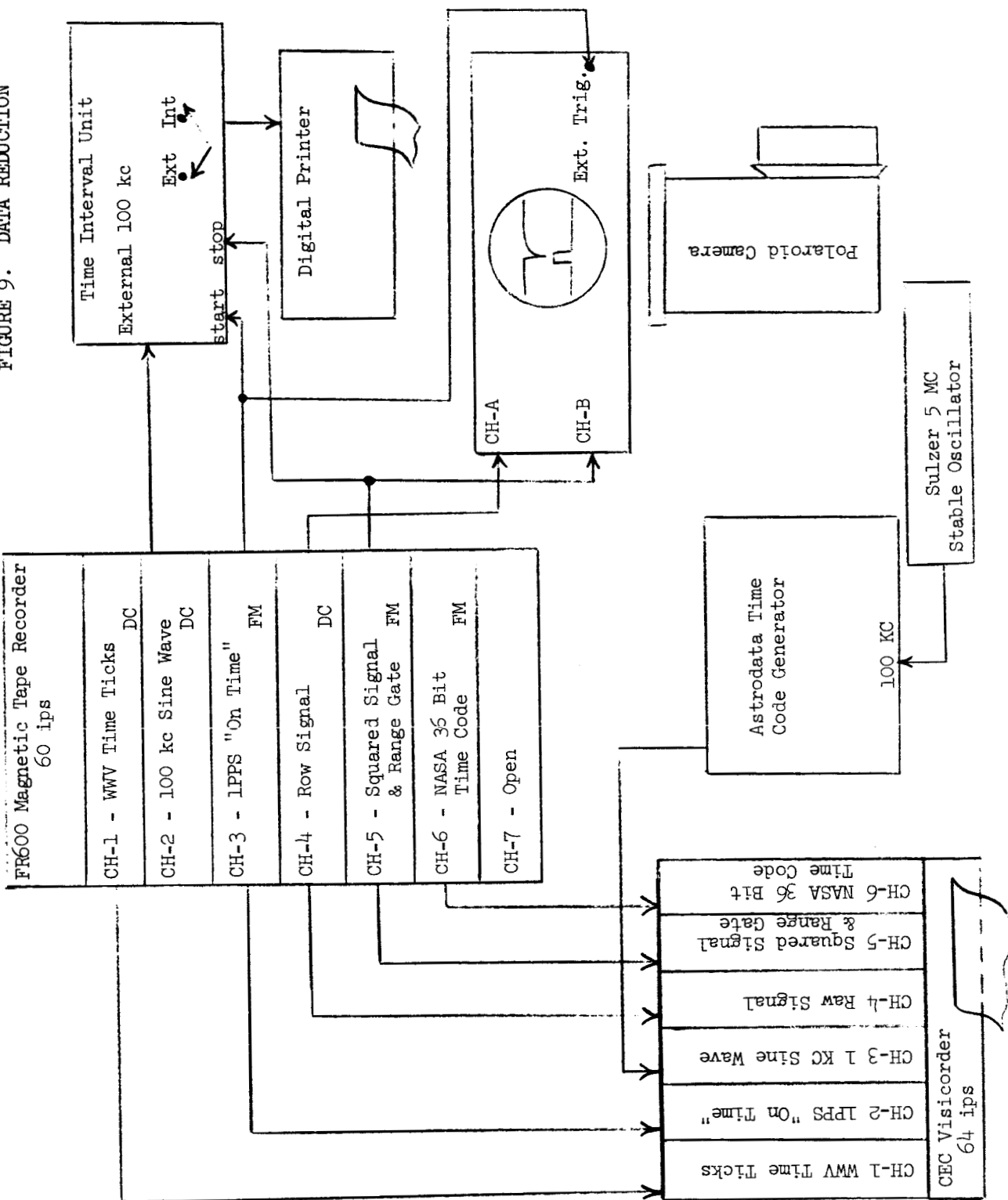


"B"

Sweep 200 microseconds/cm

Figure 8. Typical playback from magnetic tape showing the flash lamp return and its squared signal counterpart. Rise time of flash lamp signal (10-90% points) is approximately 80-100 microseconds. Squared signal risetime is  $< 5$  microseconds. The squared signal is used to stop the time interval counter to obtain accurate range measurements. Time increases from right to left.

FIGURE 9. DATA REDUCTION





time interval thus displayed was printed out on digital paper tape. Each flash sequence was played back a minimum of 12 times: first, six times against the 1 MC internal oscillator of the time interval unit, and then six times against the stable 100KC as recorded on the magnetic tape. The readings thus obtained were then averaged to give a more meaningful time interval measurement.

The satellite range information for each particular minute and second involved was obtained from the printed copy of the programmer drive tape which had been prepared on the basis of previous Minitrack data. The averaged time interval readings, as obtained above, were then compared to these computer-predicted ranges. The time differences obtained, indicated relative to our reference 1 PPS "on time" marker, when each lamp flash of a sequence occurred, or the time interval between lamp flashes. Table 1 is a record of the arrival times of the first flash of each sequence that was received. A minus sign in front of the time differences listed indicates that the lamp flash actually occurred on the satellite prior to our reference 1 PPS "on time" marker. A plus sign indicates that the lamp flash occurred after our 1 PPS "on time" marker. Listed in Column 5 are the times, relative to WWV, that the integer minute marker occurred on-board the satellite. Comparison of Column 4 and 5 indicates that the lamp flashes occur well within the  $\pm 400$  microseconds of the satellite integer minute marker.

TABLE 1

TIMING RESULTS OF FLASH #1 OF A GEOS FLASH SEQUENCE

(1)				(2)	(3)	(4)	(5)
DATE				T + $\Delta t$ EXPECTED FLASH RECEPTION TIME ( $\mu$ SEC)	(T + $\Delta t_{LMC}$ ) ACTUAL FLASH RECEPTION TIME ( $\mu$ SEC)	TIME DIFFERENCE <sup>1</sup> BETWEEN EXPECTED & ACTUALLY REC'D FLASHES ( $\mu$ SEC) (T + $\Delta t$ ) - (T + $\Delta t_{LMC}$ )	SATELLITE INTEGER <sup>1,2</sup> MINUTE MARKER OCCURRENCE ( $\mu$ SEC)
DAYS	HRS.	MIN.	SEC.				
049	10	27	00	00 <sup>S</sup> .11233	00 <sup>S</sup> .7897	-3336	-3280
		30	00	00 <sup>S</sup> .10562	00 <sup>S</sup> .7236	-3326	-3314
		32	00	00 <sup>S</sup> .10616	00 <sup>S</sup> .7292	-3324	-3297
		33	00	00 <sup>S</sup> .10797	00 <sup>S</sup> .7446	-3351	-3312
066	07	24	00	00 <sup>S</sup> .13109	00 <sup>S</sup> .13523	+414	+436
		29	00	00 <sup>S</sup> .9816	00 <sup>S</sup> .10172	+356	+463
		35	00	00 <sup>S</sup> .8887	00 <sup>S</sup> .9270	+383	+418
		44	00	00 <sup>S</sup> .11215	00 <sup>S</sup> .11610	+395	+464
066	09	36	00	00 <sup>S</sup> .9232	00 <sup>S</sup> .9695	+463	+509
		40	00	00 <sup>S</sup> .8449	00 <sup>S</sup> .8860	+411	+485
		41	00	00 <sup>S</sup> .8562	00 <sup>S</sup> .8969	+407	+475
		43	00	00 <sup>S</sup> .9142	00 <sup>S</sup> .9597	+455	+490
067	07	29	00	00 <sup>S</sup> .12207	00 <sup>S</sup> .11968	-239	-127
		34	00	00 <sup>S</sup> .9009	00 <sup>S</sup> .8778	-221	-144
		39	00	00 <sup>S</sup> .8311	00 <sup>S</sup> .8091	-220	-153
		44	00	00 <sup>S</sup> .10621	00 <sup>S</sup> .10369	-252	-181
067	09	35	00	00 <sup>S</sup> .13030	00 <sup>S</sup> .12928	-102	-136
		40	00	00 <sup>S</sup> .9915	00 <sup>S</sup> .9672	-243	-139
		43	00	00 <sup>S</sup> .8963	00 <sup>S</sup> .8774	-189	-118
		44	00	00 <sup>S</sup> .8864	00 <sup>S</sup> .8646	-218	-156
		45	00	00 <sup>S</sup> .8884	00 <sup>S</sup> .8690	-194	-144
068	07	37	00	00 <sup>S</sup> .9382	00 <sup>S</sup> .9259	-123	+16
		39	00	00 <sup>S</sup> .8395	00 <sup>S</sup> .8272	-123	+8
		43	00	00 <sup>S</sup> .7892	00 <sup>S</sup> .7802	-090	+29
		47	00	00 <sup>S</sup> .9480	00 <sup>S</sup> .9336	-144	+21
		48	00	00 <sup>S</sup> .10113	00 <sup>S</sup> .9979	-134	+21
068	09	41	00	00 <sup>S</sup> .12441	00 <sup>S</sup> .12315	-126	+21
		43	00	00 <sup>S</sup> .11198	00 <sup>S</sup> .11063	-133	+19
		45	00	00 <sup>S</sup> .10205	00 <sup>S</sup> .10078	-127	+28
		48	00	00 <sup>S</sup> .9367	00 <sup>S</sup> .9229	-138	+14
		52	00	00 <sup>S</sup> .9752	00 <sup>S</sup> .9611	-141	+63

<sup>1</sup> Minus sign indicates flash occurred prior to true "on time".

Plus sign indicates flash occurred after true "on time".

"On time" is that time referenced to cesium beam standard at the Goddard Timing Laboratory - true "on time" (i.e. referred to WWV) would necessitate the subtraction of approximately 30 microseconds from each listed time difference.

<sup>2</sup> Telephone conversation with Mr. Glen San Lwin of APL. Obtained from telemetry received at APL. Reference time used at APL is reference to true WWV on time.

Table 2 is a record of the arrival times and time intervals of a typical 7-flash sequence. As can be seen from this table, the time interval between flashes is 4 seconds  $\pm 40$  microseconds. Comparison of the data obtained from all pass sequences observed (see Appendix) indicates that this time interval between successive flashes does hold.

#### TIMING

Figure 10 is a comparison of the WWV time ticks as received and the Goddard cesium beam time standard system. This time difference indicates that the WWV time ticks appears to be a poor choice as reference for this experiment. The "true WWV on time" occurs 30 microseconds  $\pm 1$  microsecond ahead of the cesium beam standard 1 PPS. This delay, inherent in the WWV transmission circuitry has been verified both by NBS - Boulder personnel and members of the Goddard Timing Systems Section<sup>2</sup> in December 1965. The variations and drift shown in Figure 10 are in addition to and independent of this constant offset.

The purpose of the experiment was to accurately determine, relative to WWV, the start of a flash lamp sequence. It was therefore imperative that our reference 1 PPS "on time" marker be accurately set and checked constantly for drift. In addition since WWV varied so from day to day and second to second, it was thought that it would be more meaningful to reference a stable time base - the Goddard cesium standard. "On time" determination was established through the use of a highly stable secondary

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<sup>2</sup>Private conversation with Mr. S. Wardrip of the Goddard Timing Systems Section on March 28, 1966.

TABLE 2

DAY	HOUR	MIN	SEC	FLASH NO.	TIME DIFFERENCE BETWEEN EXPECTED & ACTUALLY RECD. FLASHES $\mu$ /SEC.	TIME DIFFERENCE BETWEEN SUCCESSIVE FLASHES (SEC)	TIME DIFFERENCE BETWEEN SUCCESSIVE FLASHES ( $\mu$ SEC)
068	09	48	00	1	-138	-	-
		48	04	2	-144	4.000006	+6
		48	08	3	-143	3.999999	-1
		48	12	4	-125	3.999982	-18
		48	16	5	-121	3.999996	-4
		48	20	6	-119	3.999998	-2
		28	24	7	-108	3.999989	-11

1 PPS

"On Time"

$T + \Delta t$

Expected Flash  
Reception Time

Flash

Initiated

Here

$T + \Delta t$  LMC

Actual Flash Reception Time

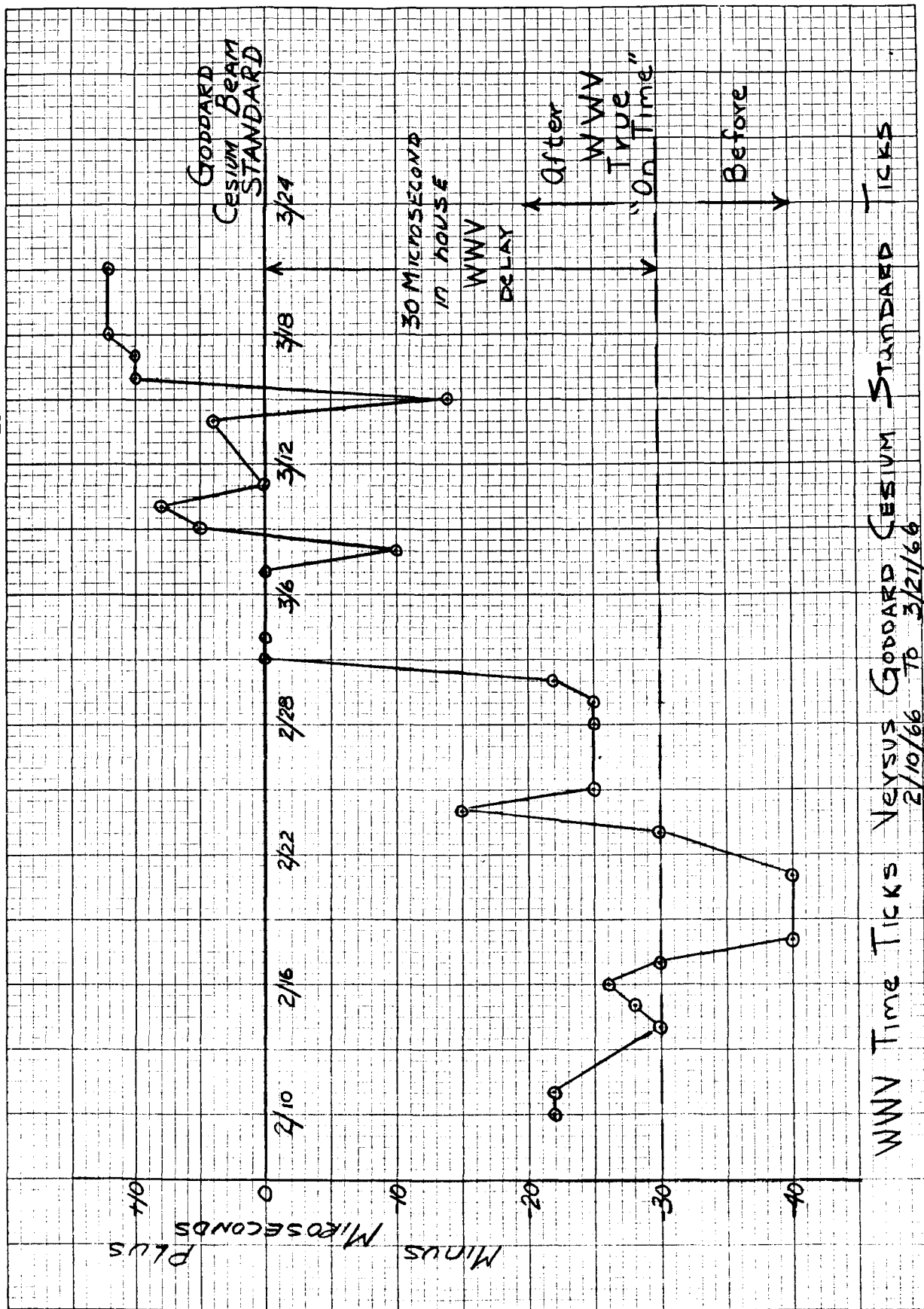


FIGURE 10

quartz frequency standard and a portable clock borrowed from the Goddard Timing Laboratory.

The portable clock was first set to within 1 microsecond of the 1 PPS output of the Goddard cesium beam standard. The portable clock was then transported to the Goddard Optical Research Facility and used to set our 1 PPS "on time" marker to within one microsecond of the portable standard. In all, our time code generator 1 PPS "on time" marker was then within 2 microseconds of the Goddard cesium beam time standard and within 32 microseconds of true time referenced to WWV. At the end of a satellite pass (usually 6-8 hours later) our 1 PPS "on time" marker was again compared against the portable clock. The difference thus obtained, on the order of minus 10 microseconds, was recorded. The portable clock was again compared to the cesium standard at Goddard. Corrections for both differences then established the drift of our 1 PPS "on time" standard from either the cesium standard or true "on time" of WWV. At the end of a pass, our 1 PPS "on time" marker occurred after (late) true WWV "on time" by 34-38 microseconds. If we correct for this estimated offset, then our time is good to  $\pm 2$  microseconds relative to "true WWV on time." It should be noted that Table 1 was not corrected for these offsets.

#### RESULTS

Table 1 gives the time differences recorded for the first lamp flash of a sequence. The time recorded is an average of 6 readings of the flash time arrival, referenced to our 1 PPS "on time" marker and corrected for

the time of flight from the predicted satellite range at that time. Since the Goddard cesium standard is ahead of "true WWV on time" by 30 microseconds, our time difference is in error by that amount plus the drift error of our time code generator. Results of the experiment indicate the following:

1. The flash lamp sequence, except for the pass data obtained on March 7, 1966, begins prior to the ground based integer U.T. minute marker "true WWV on time".
2. The flashes begin within  $\pm 400$  microseconds of the integer minute occurrence on board the satellite.
3. The time interval between flashes within a sequence is 4 seconds  $\pm 40$  microseconds.
4. The pulse duration (1/3 power points) of the observed flashes is 1.2 milliseconds  $\pm 200$  microseconds (Figures 3 through 6).
5. The lamp output risetime is on the order of 80-100 microseconds (Figures 8A&B).
6. Flash #2 of a sequence normally has the longest time interval, i.e. flash #2 occurs 4 seconds or more after the first flash of a sequence.
7. All other flash time intervals are normally less than 4 seconds.

The Appendix lists the times of arrival of all GEOS flashes photo-electrically recorded.

#### REFERENCES

1. Johns Hopkins University, Applied Physics Laboratory, "Technical Plan for a National Geodetic Satellite Program" March 1965, pp. 13-35; 60-81.
2. Systems Sciences Corporation, Technical Report #4007-2 "Plan for The Johns Hopkins University Applied Physics Laboratory Operations to Support GEOS A" October 4, 1965, Prepared under NASA Contract NASw1238, pp 4-18-4-32, 4-38 to 4-48.

#### ACKNOWLEDGEMENTS

The author wishes to acknowledge the assistance of Messrs. Edwin Reid, Harold Walker, and James MacFarlane during the setting up, running and data reduction portions of this experiment. In addition, the assistance of Dr. Henry H. Plotkin and Mr. Louis O. Caudill in the preparation of this paper is greatly appreciated.



# APPENDIX

## GEOS FLASH DETECTION

TIME (GMT)	DAYS	HRS	MIN	SEC	FLASH #	TIME DIFFERENCE <sup>1</sup> BETWEEN EXPECTED & ACTUALLY RECD. MINUTE MARKER FLASHES (11 SEC) OCCURRENCE <sup>1,2</sup> (T+Δt)-(T+Δt <sub>LMC</sub> ) (11 SEC)		
						(T+Δt)	(T+Δt <sub>LOOKC</sub> )	(T+Δt <sub>LMC</sub> )
(T)								
						</		

### SEQUENCE No. 1

049	10	27	00	1	00	11233	00 <sup>s</sup> .7900	00 <sup>s</sup> .7897	-3336	-3280
			04	2	04	11209	04 <sup>s</sup> .7870	04 <sup>s</sup> .7868	-3341	
			08	3	08	11185	08 <sup>s</sup> .7850	08 <sup>s</sup> .7852	-3333	
			12	4	12	11162	12 <sup>s</sup> .7850	12 <sup>s</sup> .7851	-3311	
			16	5	16	11139	16 <sup>s</sup> .7830	16 <sup>s</sup> .7831	-3309	
			20	6	20	11116	20 <sup>s</sup> .7410*	20 <sup>s</sup> .7411	Error	
			24	7	24	11094	24 <sup>s</sup> .7810	24 <sup>s</sup> .7812	-3282	

### SEQUENCE No. 2

049	10	30	00	1	00	10562	00 <sup>s</sup> .7240	00 <sup>s</sup> .7236	-3326	-3314
			04	2	04	10556	04 <sup>s</sup> .7210	04 <sup>s</sup> .7215	-3341	
			08	3	08	10552	08 <sup>s</sup> .7210	08 <sup>s</sup> .7206	-3346	
			12	4	12	10548	12 <sup>s</sup> .7230	12 <sup>s</sup> .7228	-3320	
			16	5	16	10544	16 <sup>s</sup> .7230	16 <sup>s</sup> .7228	-3316	
			20	6	20	10541	20 <sup>s</sup> .7240	20 <sup>s</sup> .7238	-3303	
			24	7	24	10538	24 <sup>s</sup> .7240	24 <sup>s</sup> .7239	-3299	

049	10	32	00	1	00 <sup>s</sup> .10616	00 <sup>s</sup> .7290	00 <sup>s</sup> .7292	-3324	-3297
			04	2	04 <sup>s</sup> .10625	04 <sup>s</sup> .7290	04 <sup>s</sup> .7285	-3340	
			08	3	08 <sup>s</sup> .10634	08 <sup>s</sup> .7290	08 <sup>s</sup> .7287	-3347	
			12	4	12 <sup>s</sup> .10644	12 <sup>s</sup> .7320	12 <sup>s</sup> .7319	-3325	
			16	5	16 <sup>s</sup> .10655	16 <sup>s</sup> .7320	16 <sup>s</sup> .7325	-3330	
			20	6	20 <sup>s</sup> .10665	20 <sup>s</sup> .7360	20 <sup>s</sup> .7357	-3308	
049	10	32	24	7	24 <sup>s</sup> .10676	24 <sup>s</sup> .7380	24 <sup>s</sup> .7382	-3294	

049	10	33	00	1	00.10797 <sup>s</sup>	00.7450 <sup>s</sup>	00.7446 <sup>s</sup>	-3351	-3312
			04	2	04.10812 <sup>s</sup>	04.7470 <sup>s</sup>	04.7468 <sup>s</sup>	-3344	
			08	3	08.10828 <sup>s</sup>	08.7480 <sup>s</sup>	08.7476 <sup>s</sup>	-3352	
			12	4	12.10845 <sup>s</sup>	12.7520 <sup>s</sup>	12.7519 <sup>s</sup>	-3326	
			16	5	16.10862 <sup>s</sup>	16.7530 <sup>s</sup>	16.7526 <sup>s</sup>	-3336	
			20	6	20.10879 <sup>s</sup>	20.7550 <sup>s</sup>	20.7549 <sup>s</sup>	-3330	
049	10	33	24	7	24.10897 <sup>s</sup>	24.7590 <sup>s</sup>	24.7584 <sup>s</sup>	-3313	

(T)			(T+Δt)		(T+Δt <sub>LOOKC</sub> )		(T+Δt <sub>LMC</sub> )		TIME DIFFERENCE <sup>1</sup> BETWEEN EXPECTED & ACTUALLY RECD. FLASHES (✓, SEC)		SATELLITE INTEGER MINUTE MARKER OCCURRENCE	
DAYS	HRS	MIN SEC	FLASH #	RECEPTION TIME (✓, SEC)	EXPECTED FLASH RECESSION TIME (✓, SEC)	ACTUAL FLASH REC. TIMED AGAINST LMC (✓, SEC)	ACTUAL FLASH REC. TIMED AGAINST LMC (✓, SEC)	(T+Δt) LMC	(T+Δt)-(T+Δt <sub>LMC</sub> )	(✓, SEC)	(✓, SEC)	(✓, SEC)

SEQUENCE No. 1

066	09	36	00	1	00. <sup>s</sup> 9232	00. <sup>s</sup> 9700	00. <sup>s</sup> 9695	+463	+509
			04	2	04. <sup>s</sup> 9204	04. <sup>s</sup> 9600	04. <sup>s</sup> 9593	+389	
			08	3	08. <sup>s</sup> 9177	08. <sup>s</sup> 9600	08. <sup>s</sup> 9606	+429	
			12	4	12. <sup>s</sup> 9150	12. <sup>s</sup> 9630	12. <sup>s</sup> 9630	+480	
			16	5	16. <sup>s</sup> 9124	16. <sup>s</sup> 9560	16. <sup>s</sup> 9568	+444	
			20	6	20. <sup>s</sup> 9098	20. <sup>s</sup> 9580	20. <sup>s</sup> 9578	+480	
			24	7	24. <sup>s</sup> 9072	24. <sup>s</sup> 9550	24. <sup>s</sup> 9550	+478	
<u>SEQUENCE No. 2</u>									
066	09	40	00	1	00. <sup>s</sup> 8449	00. <sup>s</sup> 8860	00. <sup>s</sup> 8860	+411	+485
			04	2	04. <sup>s</sup> 8453	04. <sup>s</sup> 8850	04. <sup>s</sup> 8851	+398	
			08	3	08. <sup>s</sup> 8457	08. <sup>s</sup> 8870	08. <sup>s</sup> 8871	+414	
			12	4	12. <sup>s</sup> 8461	12. <sup>s</sup> 8670	12. <sup>s</sup> 8673	+212	
			16	5	16. <sup>s</sup> 8467	16. <sup>s</sup> 8910	16. <sup>s</sup> 8906	+439	
			20	6	20. <sup>s</sup> 8472	20. <sup>s</sup> 8910	20. <sup>s</sup> 8906	+434	
			24	7	24. <sup>s</sup> 8479	24. <sup>s</sup> 8950	24. <sup>s</sup> 8949	+470	

TIME DAYS	(T) (GMT)		FLASH #	(T+Δt)		(T+Δt <sub>LOOKC</sub> )		(T+Δt <sub>LMC</sub> )		TIME DIFFERENCE <sup>1</sup> BETWEEN EXPECTED & ACTUALLY RECD. FLASHES ( " SEC)		SATELLITE INTEGER MINUTE MARKER OCCURRENCE <sub>1,2</sub> ( " SEC)	
	HRS MIN SEC			( " SEC)		( " SEC)		( " SEC)		(T+Δt) - (T+Δt <sub>LMC</sub> ) ( " SEC)			

SEQUENCE No. 3

066	09	41	00	1	00.8562	<sup>S</sup> 00.8960	<sup>S</sup> 00.8969	+407	+475
		04		2	04.8573	<sup>S</sup> 04.8980	<sup>S</sup> 04.8974	+401	
		08		3	08.8586	<sup>S</sup> 08.9010	<sup>S</sup> 08.9002	+416	
		12		4	12.8599	<sup>S</sup> 12.9040	<sup>S</sup> 12.9038	+439	
		16		5	16.8612	<sup>S</sup> 16.9060	<sup>S</sup> 16.9054	+442	
		20		6	20.8626	<sup>S</sup> 20.9060	<sup>S</sup> 20.9065	+439	
		24		7	24.8641	<sup>S</sup> 24.9110	<sup>S</sup> 24.9102	+461	

SEQUENCE No. 4

066	09	43	00	1	00.9142	<sup>S</sup> 00.9580	<sup>S</sup> 00.9597	+455	+490
		04		2	04.9167	<sup>S</sup> 04.9570	<sup>S</sup> 04.9561	+397	
		08		3	08.9194	<sup>S</sup> 08.9630	<sup>S</sup> 08.9618	+424	
		12		4	12.9222	<sup>S</sup> 12.9680	<sup>S</sup> 12.9687	+465	
		16		5	16.9250	<sup>S</sup> 16.9680	<sup>S</sup> 16.9675	+425	
		20		6	20.9278	<sup>S</sup> 20.9720	<sup>S</sup> 20.9725	+447	
		24		7	24.9307	<sup>S</sup> 24.9790	<sup>S</sup> 24.9780	+473	

(T) TIME (G:IT)			FLASH #		(T+Δt) EXPECTED FLASH RECEPTION TIME (SEC)	(T+Δt) ACTUAL FLASH REC. TIMED AGAINST LOOKC (SEC)	(T+Δt) ACTUAL FLASH REC. TIMED AGAINST LMC (SEC)	TIME DIFFERENCE <sup>1</sup> BETWEEN EXPECTED & ACTUALLY RECD. FLASHES (T+Δt) - (T+Δt) <sub>LMC</sub>		SATELLITE INTEGER MINUTE MARKER OCCURRENCE <sub>1,2</sub>	
DAYS	HRS	MIN	SEC								

SEQUENCE No. 3

066	07	35	00	1	00 <sup>S</sup> .8887	00 <sup>S</sup> .9260	00 <sup>S</sup> .9270	+383		+418	
		04		2	04 <sup>S</sup> .8902	04 <sup>S</sup> .9260	04 <sup>S</sup> .9264	+362			
		08		3	08 <sup>S</sup> .8917						
		12		4	12 <sup>S</sup> .8932	12 <sup>S</sup> .9320	12 <sup>S</sup> .9316	+384			
		16		5	16 <sup>S</sup> .8949	16 <sup>S</sup> .9350	16 <sup>S</sup> .9338	+389			
		20		6	20 <sup>S</sup> .8965	20 <sup>S</sup> .9370	20 <sup>S</sup> .9371	+406			
		24		7	24 <sup>S</sup> .8982						

SEQUENCE No. 4

066	07	44	00	1	00 <sup>S</sup> .11215	00 <sup>S</sup> .11620	00 <sup>S</sup> .11610	+395		+464	
		04		2	04 <sup>S</sup> .11258	04 <sup>S</sup> .11670	04 <sup>S</sup> .11697	+439			
		08		3	08 <sup>S</sup> .11303	08 <sup>S</sup> .11760	08 <sup>S</sup> .11749	+446			
		12		4	12 <sup>S</sup> .11347	12 <sup>S</sup> .11750	12 <sup>S</sup> .11767	+420			
		16		5	16 <sup>S</sup> .11392	16 <sup>S</sup> .11830	16 <sup>S</sup> .11832	+440			
		20		6	20 <sup>S</sup> .11437	20 <sup>S</sup> .11850	20 <sup>S</sup> .11845	+408			
		24		7	24 <sup>S</sup> .11482	24 <sup>S</sup> .11930	24 <sup>S</sup> .11929	+447			

TIME DAYS	(T) (GMT)	HRS	MIN	SEC	#	FLASH RECEPTION TIME ( $\mu$ SEC)	(T+ $\Delta t$ ) EXPECTED FLASH RECEPTION TIME ( $\mu$ SEC)	(T+ $\Delta t$ ) ACTUAL FLASH REC. TIMED AGAINST LMC ( $\mu$ SEC)	(T+ $\Delta t$ ) LOOKC ( $\mu$ SEC)	TIME DIFFERENCE BETWEEN EXPECTED & ACTUALLY RECD. FLASHES ( $\mu$ SEC) (T+ $\Delta t$ ) - (T+ $\Delta t$ ) LMC	SATELLITE INTEGER MINUTE MARKER OCCURRENCE ( $\mu$ SEC) <sup>1,2</sup>

SEQUENCE No. 1

067	07	29	00	1		00.12207	<sup>s</sup> 00.11970	<sup>s</sup> 00.11968	-239	-127
		04		2		04.12155	<sup>s</sup> 04.11920	<sup>s</sup> 04.11908	-247	
		08		3		08.12102	<sup>s</sup> 08.11850	<sup>s</sup> 08.11860	-242	
		12		4		12.12051	<sup>s</sup> 12.11820	<sup>s</sup> 12.11820	-231	
		16		5		16.12000	<sup>s</sup> 16.11760	<sup>s</sup> 16.11756	-244	
		20		6		20.11949	<sup>s</sup> 20.11720	<sup>s</sup> 20.11715	-234	
		24		7		24.11898	<sup>s</sup> 24.11700	<sup>s</sup> 24.11703	-195	

SEQUENCE No. 2

067	07	33	00	1		00.9504	<sup>s</sup> 04.9220	<sup>s</sup> 04.9231	-237	-160
		04		2		04.9468	<sup>s</sup> 08.9180	<sup>s</sup> 08.9187	-245	
		08		3		08.9432	<sup>s</sup> 12.9180	<sup>s</sup> 12.9188	-209	
		12		4		12.9397	<sup>s</sup> 16.9130	<sup>s</sup> 16.9122	-240	
		16		5		16.9362	<sup>s</sup> 20.9110	<sup>s</sup> 20.9111	-217	
		20		6		20.9328	<sup>s</sup> 24.9080	<sup>s</sup> 24.9086	-208	
		24		7		24.9294				

TIME DAYS	(T) (GMT)	FLASH #	TIME DIFFERENCE <sup>1</sup>			SATELLITE INTEGER MINUTE MARKER OCCURRENCE <sup>1,2</sup> (.1 SEC)
			(T+Δt)	(T+Δt <sub>LOOKC</sub> )	(T+Δt <sub>LMC</sub> )	
			EXPECTED FLASH RECEPTION TIME (.1 SEC)	ACTUAL FLASH REC. TIMED AGAINST LOOKC (.1 SEC)	ACTUALLY RECD. FLASHES (.1 SEC) (T+Δt) - (T+Δt <sub>LMC</sub> )	

SEQUENCE No. 3

067	07	34	00	1		00.9009 <sup>S</sup>	00.8770 <sup>S</sup>	00.8778 <sup>S</sup>	-221	-144
		04		2		04.8980 <sup>S</sup>	04.8680 <sup>S</sup>	04.8683 <sup>S</sup>	-297	
		08		3		08.8951 <sup>S</sup>	08.8690 <sup>S</sup>	08.8703 <sup>S</sup>	-249	
		12		4		12.8922 <sup>S</sup>				
		16		5		16.8894 <sup>S</sup>	16.8660 <sup>S</sup>	16.8660 <sup>S</sup>	-234	
		20		6		20.8866 <sup>S</sup>	20.8630 <sup>S</sup>	20.8626 <sup>S</sup>	-240	
		24		7		24.8839 <sup>S</sup>	24.8610 <sup>S</sup>	24.8609 <sup>S</sup>	-230	

SEQUENCE No. 4

067	07	39	00	1		00.8311 <sup>S</sup>	00.8090 <sup>S</sup>	00.8091 <sup>S</sup>	-220	-153
		04		2		04.8324 <sup>S</sup>	04.8080 <sup>S</sup>	04.8084 <sup>S</sup>	-240	
		08		3		08.8338 <sup>S</sup>	08.8090 <sup>S</sup>	08.8101 <sup>S</sup>	-237	
		12		4		12.8352 <sup>S</sup>	12.8150 <sup>S</sup>	12.8151 <sup>S</sup>	-201	
		16		5		16.8367 <sup>S</sup>	16.8130 <sup>S</sup>	16.8134 <sup>S</sup>	-233	
		20		6		20.8382 <sup>S</sup>	20.8160 <sup>S</sup>	20.8163 <sup>S</sup>	-219	
		24		7		24.8398 <sup>S</sup>	24.8200 <sup>S</sup>	24.8201 <sup>S</sup>	-197	

TIME DAYS	(T) (GMT)	HRS	MIN	SEC	FLASH #	(T+Δt) RECEIVED TIME	(T+Δt) <sub>LOOKC</sub> FLASH RECD.	(T+Δt) <sub>LMC</sub> ACTUAL FLASH REC. TIMED AGAINST LMC	TIME DIFFERENCE <sup>1</sup> BETWEEN EXPECTED & ACTUALLY RECD. FLASHES (T+Δt) - (T+Δt) <sub>LMC</sub>		SATELLITE INTEGER MINUTE MARKER OCCURRENCE <sub>1,2</sub> (μ SEC)
						(μ SEC)	(μ SEC)	(μ SEC)			

SEQUENCE NO. 5

067	07	44	00	1		<sup>S</sup> 00.10621	<sup>S</sup> 00.10360	<sup>S</sup> 00.10369	-252	-181
		04		2		<sup>S</sup> 04.10665	<sup>S</sup> 04.10420	<sup>S</sup> 04.10427	-238	
		08		3		<sup>S</sup> 08.10710	<sup>S</sup> 08.10450	<sup>S</sup> 08.10452	-258	
		12		4		<sup>S</sup> 12.10755	<sup>S</sup> 12.10530	<sup>S</sup> 12.10532	-223	
		16		5		<sup>S</sup> 16.10801	<sup>S</sup> 16.10580	<sup>S</sup> 16.10581	-220	
		20		6		<sup>S</sup> 20.10847	<sup>S</sup> 20.10620	<sup>S</sup> 20.10618	-229	
		24		7		<sup>S</sup> 24.10893	<sup>S</sup> 24.10670	<sup>S</sup> 24.10683	-210	



TIME DAYS	(T) HRS	MIN	SEC	#	FLASH RECEPTION TIME ( $\mu$ SEC)	EXPECTED FLASH RECEPTION TIME ( $\mu$ SEC)	ACTUAL FLASH REC. TIMED AGAINST LMC ( $\mu$ SEC)	(T+ $\Delta$ t) LOOKC ( $\mu$ SEC)	(T+ $\Delta$ t) LMC ( $\mu$ SEC)	TIME DIFFERENCE <sup>1</sup> BETWEEN EXPECTED & ACTUALLY RECD. FLASHES ( $\mu$ SEC) (T+ $\Delta$ t) - (T+ $\Delta$ t) LMC	SATELLITE INTEGER MINUTE MARKER OCCURRENCE ( $\mu$ SEC) <sup>1,2</sup>

SEQUENCE No. 1

067	09	35	00	1	00.13030	<sup>S</sup> 00.12880	<sup>S</sup> 00.12928			-102	-136
		04		2	<sup>S</sup> 04.12980	<sup>S</sup> 04.12760	<sup>S</sup> 04.12764			-216	
		08		3	<sup>S</sup> 08.12930	<sup>S</sup> 08.12710	<sup>S</sup> 08.12717			-213	
		12		4	<sup>S</sup> 12.12881	<sup>S</sup> 12.12710	<sup>S</sup> 12.12719			-161	
		16		5	<sup>S</sup> 16.12832	<sup>S</sup> 16.12640	<sup>S</sup> 16.12643			-189	
		20		6	<sup>S</sup> 20.12783	<sup>S</sup> 20.12710	<sup>S</sup> 20.12512			-271	
		24		7	<sup>S</sup> 24.12735	<sup>S</sup> 24.12570	<sup>S</sup> 24.12575			-160	

SEQUENCE No. 2

067	09	40	00	1	<sup>S</sup> 00.9915	<sup>S</sup> 00.9680	<sup>S</sup> 00.9672			-243	-139
		04		2	<sup>S</sup> 04.9884	<sup>S</sup> 04.9640	<sup>S</sup> 04.9625			-259	
		08		3	<sup>S</sup> 08.9854	<sup>S</sup> 08.9630	<sup>S</sup> 08.9623			-231	
		12		4	<sup>S</sup> 12.9824	<sup>S</sup> 12.9600	<sup>S</sup> 12.9597			-227	
		16		5	<sup>S</sup> 16.9795						
		20		6	<sup>S</sup> 20.9766	<sup>S</sup> 20.9570	<sup>S</sup> 20.9587			-213	
		24		7	<sup>S</sup> 24.9737	<sup>S</sup> 24.9550	<sup>S</sup> 24.9537			-200	

(T)		(T+Δt)		(T+Δt <sub>LOOKC</sub> )		(T+Δt <sub>LMC</sub> )		TIME DIFFERENCE <sup>1</sup> BETWEEN EXPECTED & ACTUALLY REC. FLASHES (Δ SEC) (T+Δt)-(T+Δt <sub>LMC</sub> )		SATELLITE INTEGER MINUTE MARKER OCCURRENCE (Δ SEC) <sup>1,2</sup>	
TIME DAYS	(GMT) HRS. MIN SEC	FLASH #	EXPECTED FLASH RECEPTION TIME (Δ SEC)	ACTUAL FLASH REC. TIMED AGAINST 100 KC (Δ SEC)	ACTUAL FLASH REC. TIMED AGAINST 1 MC (Δ SEC)	ACTUAL FLASH REC. TIMED AGAINST 1 MC (Δ SEC)					
<u>SEQUENCE #3</u>											
067	09 43 00	1	00 <sup>s</sup> .8963	00 <sup>s</sup> .8990	00 <sup>s</sup> .8774		-189			-118	
	04	2	04 <sup>s</sup> .8952	04 <sup>s</sup> .8850	04 <sup>s</sup> .8844		-108				
	08	3	08 <sup>s</sup> .8943	08 <sup>s</sup> .8800	08 <sup>s</sup> .8799		-144				
	12	4	12 <sup>s</sup> .8933	12 <sup>s</sup> .8780	12 <sup>s</sup> .8741		-192				
	16	5	16 <sup>s</sup> .8924	16 <sup>s</sup> .8880	16 <sup>s</sup> .8792		-132				
	20	6	20 <sup>s</sup> .8916	20 <sup>s</sup> .8800	20 <sup>s</sup> .8773		-143				
	24	7	24 <sup>s</sup> .8909	24 <sup>s</sup> .8910	24 <sup>s</sup> .8865		-034				
<u>SEQUENCE #4</u>											
067	09 44 00	1	00 <sup>s</sup> .8864	00 <sup>s</sup> .8650	00 <sup>s</sup> .8646		-218			-156	
	04	2	04 <sup>s</sup> .8861	04 <sup>s</sup> .8630	04 <sup>s</sup> .8630		-231				
	08	3	08 <sup>s</sup> .8859	08 <sup>s</sup> .8640	08 <sup>s</sup> .8635		-224				
	12	4	12 <sup>s</sup> .8858	12 <sup>s</sup> .8640	12 <sup>s</sup> .8646		-212				
	16	5	16 <sup>s</sup> .8857	16 <sup>s</sup> .8630	16 <sup>s</sup> .8626		-230				
	20	6	20 <sup>s</sup> .8857	20 <sup>s</sup> .8650	20 <sup>s</sup> .8655		-202				
	24	7	24 <sup>s</sup> .8857	24 <sup>s</sup> .8670	24 <sup>s</sup> .8663		-193				

TIME DAYS		HRS.	MIN	SEC	#	(T+Δt) EXPECTED FLASH RECEPTION TIME (.1 SEC)	(T+Δt <sub>100KC</sub> ) ACTUAL FLASH REC. TIMED AGAINST 100 KC (.1 SEC)	(T+Δt <sub>1MC</sub> ) ACTUAL FLASH REC. TIMED AGAINST 1 MC (.1 SEC)	TIME DIFFERENCE <sup>1</sup> BETWEEN EXPECTED & ACTUALLY RECD. FLASHES (.1 SEC) (T+Δt) - (T+Δt <sub>1MC</sub> )	SATELLITE INTEGER MINUTE MARKER 1, OCCURRENCE(.1 SEC)
<u>SEQUENCE #5</u>										
067	09	45	00	1	00 <sup>s</sup> .8884	00 <sup>s</sup> .8680	00 <sup>s</sup> .8690	-194	-144	
		04		2	04 <sup>s</sup> .8890	04 <sup>s</sup> .8670	04 <sup>s</sup> .8670	-220		
		08		3	08 <sup>s</sup> .8895	08 <sup>s</sup> .8670	08 <sup>s</sup> .8669	-226		
		12		4	12 <sup>s</sup> .8902	12 <sup>s</sup> .8700	12 <sup>s</sup> .8705	-197		
		16		5	16 <sup>s</sup> .8909	16 <sup>s</sup> .8710	16 <sup>s</sup> .8715	-194		
		20		6	20 <sup>s</sup> .8912	20 <sup>s</sup> .8720	20 <sup>s</sup> .8722	-190		
		24		7	24 <sup>s</sup> .8925	24 <sup>s</sup> .8740	24 <sup>s</sup> .8736	-189		

TIME DAYS	(T) (GMT)		FLASH #	(T+Δt) (T+Δt <sub>LOOKC</sub> )		(T+Δt) (T+Δt <sub>LMC</sub> )		TIME DIFFERENCE <sup>1</sup> BETWEEN EXPECTED & ACTUALLY RECD. FLASHES (μ SEC) (T+Δt) - (T+Δt <sub>LMC</sub> )	SATELLITE INTEGER MINUTE MARKER OCCURRENCE <sup>1,2</sup> (μ SEC)
	HRS	MIN SEC		(μ SEC)		(μ SEC)			
				(μ SEC)	(μ SEC)	(μ SEC)	(μ SEC)		

SEQUENCE No. 1

068	07	37	00	1	00.9382	<sup>S</sup> 00.9260	<sup>S</sup> 00.9259	-123	+16
		04		2	04.9342	<sup>S</sup> 04.9230	<sup>S</sup> 04.9227	-115	
		08		3	08.9305	<sup>S</sup> 08.9170	<sup>S</sup> 08.9176	-129	
		12		4	12.9266				
		16		5	16.9229				
		20		6	20.9191				
		24		7	24.9154	<sup>S</sup> 24.9080	<sup>S</sup> 24.9079	-075	

SEQUENCE No. 2

068	07	39	00	1	00.8395	<sup>S</sup> 00.8270	<sup>S</sup> 00.8272	-123	+08
		04		2	04.8370	<sup>S</sup> 04.8240	<sup>S</sup> 04.8245	-125	
		08		3	08.8344	<sup>S</sup> 08.8230	<sup>S</sup> 08.8232	-112	
		12		4	12.8320	<sup>S</sup> 12.8200	<sup>S</sup> 12.8209	-111	
		16		5	16.8295	<sup>S</sup> 16.8190	<sup>S</sup> 16.8191	-104	
		20		6	20.8272	<sup>S</sup> 20.8180	<sup>S</sup> 20.8178	-094	
		24		7	24.8249	<sup>S</sup> 24.8170	<sup>S</sup> 24.8174	-075	

TIME DAYS	(GMT)	HRS	MIN	SEC	#	(T+Δt) EXPECTED FLASH RECEPTION TIME (SEC)	(T+Δt) ACTUAL FLASH REC. TIMED AGAINST LMC (SEC)	(T+Δt) ACTUAL FLASH REC. TIMED AGAINST LMC (SEC)	TIME DIFFERENCE <sup>1</sup> BETWEEN EXPECTED & ACTUALLY RECD. FLASHES (T+Δt) - (T+Δt) <sub>LMC</sub>		SATELLITE INTEGER MINUTE MARKER OCCURRENCE (SEC) <sup>1,2</sup>

SEQUENCE No. 3

068	07	43	00	1		00. <sup>s</sup> 7892	00. <sup>s</sup> 7800	00. <sup>s</sup> 7802	-090		+29
		04		2		04. <sup>s</sup> 7903	04. <sup>s</sup> 7800	04. <sup>s</sup> 7817	-086		
		08		3		08. <sup>s</sup> 7914	08. <sup>s</sup> 7820	08. <sup>s</sup> 7833	-081		
		12		4		12. <sup>s</sup> 7926	12. <sup>s</sup> 7860	12. <sup>s</sup> 7862	-064		
		16		5		16. <sup>s</sup> 7938	16. <sup>s</sup> 7860	16. <sup>s</sup> 7868	-070		
		20		6		20. <sup>s</sup> 7955	20. <sup>s</sup> 7860	20. <sup>s</sup> 7863	-092		
		24		7		24. <sup>s</sup> 7965	24. <sup>s</sup> 7940	24. <sup>s</sup> 7945	-020		

068	07	47	00	1		00. <sup>s</sup> 9480		00. <sup>s</sup> 9336	-144		+21
		04		2		04. <sup>s</sup> 9520		04. <sup>s</sup> 9365	-155		
		08		3		08. <sup>s</sup> 9560		08. <sup>s</sup> 9417	-143		
		12		4		12. <sup>s</sup> 9601		12. <sup>s</sup> 9479	-122		
		16		5		16. <sup>s</sup> 9642		16. <sup>s</sup> 9504	-138		
		20		6		20. <sup>s</sup> 9683		20. <sup>s</sup> 9563	-120		
		24		7		24. <sup>s</sup> 9725		24. <sup>s</sup> 9630	-095		

(T)		FLASH		(T+Δt)		(T+Δt) <sub>LOOKC</sub>		(T+Δt) <sub>LMC</sub>		TIME DIFFERENCE <sup>1</sup> BETWEEN EXPECTED & ACTUALLY RECD. MINUTE MARKER FIASHES (μSEC) (T+Δt) - (T+Δt) <sub>LMC</sub>		SATELLITE INTEGER OCCURRENCE (μSEC) <sup>1,2</sup>	
DAYS	HRS	MIN	SEC	#	(μ SEC)	(μ SEC)	(μ SEC)	(μ SEC)	(μ SEC)				
SEQUENCE No. 5													
068	07	48	00	1	<sup>S</sup> 00.10113			<sup>S</sup> 00.9979		-134			+21
			04	2	<sup>S</sup> 04.10158			<sup>S</sup> 04.10020		-138			
			08	3	<sup>S</sup> 08.10202			<sup>S</sup> 08.10056		-146			
			12	4	<sup>S</sup> 12.10247			<sup>S</sup> 12.10135		-112			
			16	5	<sup>S</sup> 16.10293			<sup>S</sup> 16.10184		-109			
			20	6	<sup>S</sup> 20.10338			<sup>S</sup> 20.10235		-113			
			24	7	<sup>S</sup> 24.10384			<sup>S</sup> 24.10300		-084			

TIME DAYS	HRS	MIN	SEC	FLASH #	(T+Δt) EXPECTED RECEPTION TIME (.1 SEC)	(T+Δt <sub>100KC</sub> ) ACTUAL FLASH REC. TIMED AGAINST 100 KC (.1 SEC)	(T+Δt <sub>LMC</sub> ) ACTUAL FLASH REC. TIMED AGAINST LMC (.1 SEC)	TIME DIFFERENCE <sup>1</sup> BETWEEN EXPECTED & ACTUALLY RECD. FLASHES (.1 SEC) (T+Δt) - (T+Δt <sub>LMC</sub> )	SATELLITE INTEGER MINUTE MARKER OCCURRENCE (.1 SEC) <sup>1,2</sup>
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SEQUENCE NO. 1

068	09	41	00	1	00 <sup>S</sup> .12441	00 <sup>S</sup> .12200	00 <sup>S</sup> .12315	-126	+21
		04		2	04 <sup>S</sup> .12397	04 <sup>S</sup> .12240	04 <sup>S</sup> .12234	-153	
		08		3	08 <sup>S</sup> .12352	08 <sup>S</sup> .12200	08 <sup>S</sup> .12201	-151	
		12		4	12 <sup>S</sup> .12308	12 <sup>S</sup> .12210	12 <sup>S</sup> .12208	-100	
		16		5	16 <sup>S</sup> .12264	16 <sup>S</sup> .12150	16 <sup>S</sup> .12161	-103	
		20		6	20 <sup>S</sup> .12220	20 <sup>S</sup> .12120	20 <sup>S</sup> .12118	-102	
		24		7	24 <sup>S</sup> .12176	24 <sup>S</sup> .12100	24 <sup>S</sup> .12095	-081	

SEQUENCE NO. 2

068	09	43	00	1	00 <sup>S</sup> .11198	00 <sup>S</sup> .11060	00 <sup>S</sup> .11063	-133	+19
		04		2	00 <sup>S</sup> .11160	04 <sup>S</sup> .11030	04 <sup>S</sup> .11023	-137	
		08		3	08 <sup>S</sup> .11123	08 <sup>S</sup> .11098	08 <sup>S</sup> .10984	-139	
		12		4	12 <sup>S</sup> .11086	12 <sup>S</sup> .10950	12 <sup>S</sup> .10964	-122	
		16		5	16 <sup>S</sup> .11049	16 <sup>S</sup> .10930	16 <sup>S</sup> .10929	-120	
		20		6	20 <sup>S</sup> .11013	20 <sup>S</sup> .10910	20 <sup>S</sup> .10906	-107	
		24		7	24 <sup>S</sup> .10977	24 <sup>S</sup> .10890	24 <sup>S</sup> .10890	-087	

TIME		DAYS	HRS	MIN	SEC	FLASH RECEPTION		FLASH REC.		ACTUAL FLASH REC.		TIME DIFFERENCE <sup>1</sup>		SATELLITE INTEGER MINUTE MARKER OCCURRENCE (μSEC) <sup>1,2</sup>
#						(T+Δt) (μSEC)	EXPECTED RECEPTION TIME (μSEC)	100 KC (μSEC)	(T+Δt <sub>100KC</sub> )	ACTUAL FLASH REC. TIMED AGAINST (μSEC)	(T+Δt <sub>1MC</sub> )	ACTUAL FLASH REC. TIMED AGAINST 1MC (μSEC)	BETWEEN EXPECTED & ACTUALLY RECD. FLASHES (μSEC) (T+Δt) - (T+Δt <sub>1MC</sub> )	
SEQUENCE NO. 3														
068	09	45	00	1	00 <sup>S</sup> .10205	00 <sup>S</sup> .10070	00 <sup>S</sup> .10078	-127					+28	
		04		2	04 <sup>S</sup> .10172	04 <sup>S</sup> .10040	04 <sup>S</sup> .10037	-135						
		08		3	08 <sup>S</sup> .10149	08 <sup>S</sup> .10020	08 <sup>S</sup> .10016	-133						
		12		4	12 <sup>S</sup> .10122	12 <sup>S</sup> .10020	12 <sup>S</sup> .10014	-108						
		16		5	16 <sup>S</sup> .10095	16 <sup>S</sup> .9990	16 <sup>S</sup> .9989	-094						
		20		6	20 <sup>S</sup> .10064	20 <sup>S</sup> .9970	20 <sup>S</sup> .9970	-094						
		24		7	24 <sup>S</sup> .10043	24 <sup>S</sup> .9950	24 <sup>S</sup> .9958	-085						
SEQUENCE NO. 4														
068	09	48	00	1	00 <sup>S</sup> .9367	00 <sup>S</sup> .9230	00 <sup>S</sup> .9229	-138					+14	
		04		2	04 <sup>S</sup> .9358	04 <sup>S</sup> .9210	04 <sup>S</sup> .9214	-144						
		08		3	08 <sup>S</sup> .9351	08 <sup>S</sup> .9210	08 <sup>S</sup> .9208	-143						
		12		4	12 <sup>S</sup> .9343	12 <sup>S</sup> .9220	12 <sup>S</sup> .9218	-125						
		16		5	16 <sup>S</sup> .9337	16 <sup>S</sup> .9220	16 <sup>S</sup> .9216	-121						
		20		6	20 <sup>S</sup> .9331	20 <sup>S</sup> .9220	20 <sup>S</sup> .9212	-119						
		24		7	24 <sup>S</sup> .9325	24 <sup>S</sup> .9230	24 <sup>S</sup> .9217	-108						



TIME				FLASH RECEPTION TIME #	(T+Δt)	(T+Δt <sub>100KC</sub> )	(T+Δt <sub>LMC</sub> )	TIME DIFFERENCE <sup>1</sup> BETWEEN EXPECTED & ACTUALLY RECD. FLASHES (μSEC) (T+Δt) - (T+Δt <sub>LMC</sub> )	SATELLITE INTEGER MINUTE MARKER OCCURRENCE (μSEC) <sup>1,2</sup>
DAYS	HRS.	MIN	SEC		EXPECTED FLASH TIMED AGAINST 100 KC (μSEC)	ACTUAL FLASH REC. TIMED AGAINST LMC (μSEC)			
SEQUENCE NO. 5									
068	09	52	00	1	00 <sup>s</sup> .9752	00 <sup>s</sup> .9620	00 <sup>s</sup> .9611	-141	+63
		04		2	04 <sup>s</sup> .9723	04 <sup>s</sup> .9630	04 <sup>s</sup> .9624	-099	
		08		3	08 <sup>s</sup> .9794	08 <sup>s</sup> .9640	08 <sup>s</sup> .9645	-149	
		12		4	12 <sup>s</sup> .9810	12 <sup>s</sup> .9690	12 <sup>s</sup> .9690	-120	
		16		5	16 <sup>s</sup> .9838	16 <sup>s</sup> .9710	16 <sup>s</sup> .9710	-128	
		20		6	20 <sup>s</sup> .9861	20 <sup>s</sup> .9730	20 <sup>s</sup> .9739	-122	
		24		7	24 <sup>s</sup> .9883	24 <sup>s</sup> .9790	24 <sup>s</sup> .9792	-091	

<sup>1</sup> Minus sign indicates flash occurred prior true "on time"  
Plus sign indicates flash occurred after true "on time"

"On time" is that time referenced to cesium beam standard time ticks at Goddard Timing Laboratory - true  
"on time" would necessitate the subtraction of approximately 30 microseconds from each listed time difference.

<sup>2</sup> Telephone conversation with Mr. Glen San Lwin, APL. The data was obtained from telemetry information received at APL. Reference time used at APL is referenced to true "on time" reference to WWV.